N24 – Bonding

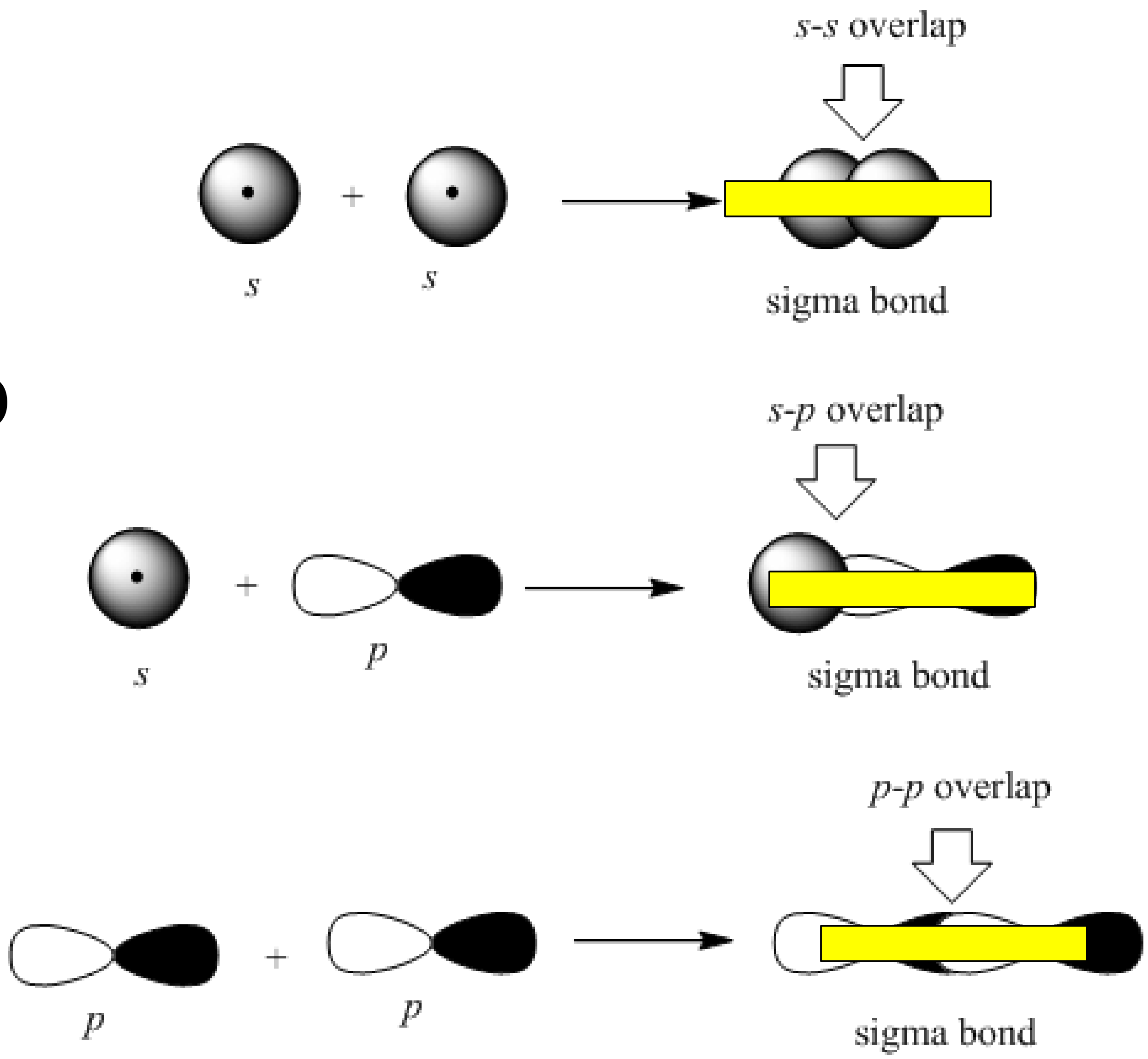
Sigma and Pi Bonds

Types of Bonds

- When we say “types of bonds” people often assume we mean single, double, triple.
- BUT we can also be talking about how the bonds are formed in 3-dimensional space, describing how the orbitals overlap to form the bond.

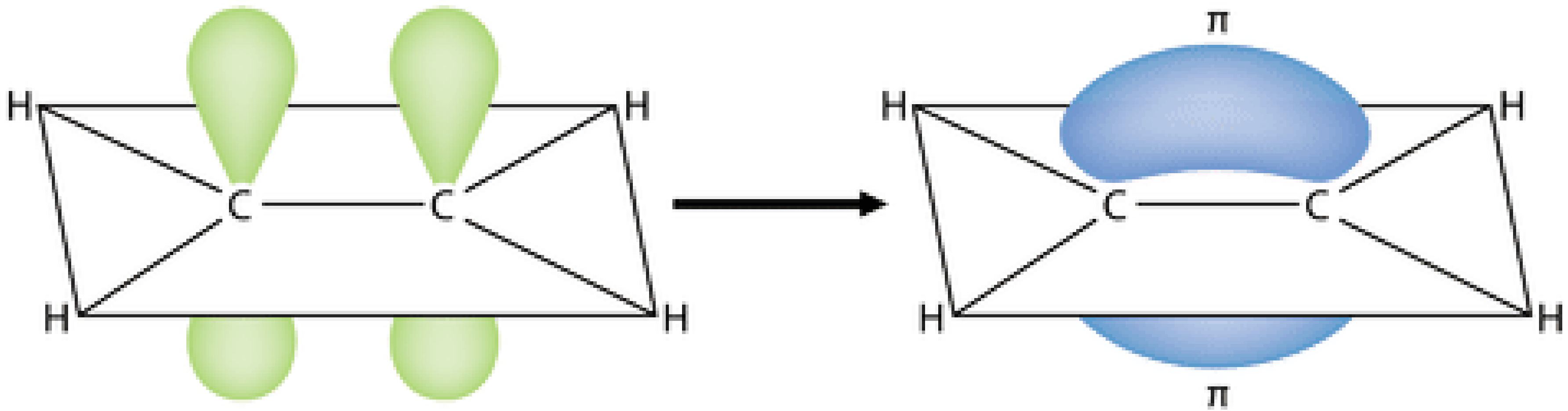
Sigma Bond

- A **sigma (*s or* σ) bond** **forms when the atomic orbitals of two atoms line up along the axis directly between the nuclei.**
  - Either standard atomic orbitals or hybrids
    - *s*-*s*, *p*-*p*, hybrid-hybrid, *s*-hybrid, etc.



Pi Bond

- **A pi (*p* or *π*) bond forms when the atomic orbitals of two atoms line up above and below the plane where the nuclei are.**
  - The unhybridized p orbitals from the two atoms that are parallel to each other.



Strength of Bonds

- s bonds are stronger than *p* bonds.
  - Sigma orbitals directly overlap between the nuclei
  - Pi bonds are reaching up and over, they are further apart and less overlap than sigma bonds
    - That makes them weaker.

When Do You Have Each Kind?

Single Bond
1 sigma bond

Double Bond
1 sigma bond
1 pi bond

Triple Bond
1 sigma bond
2 pi bonds

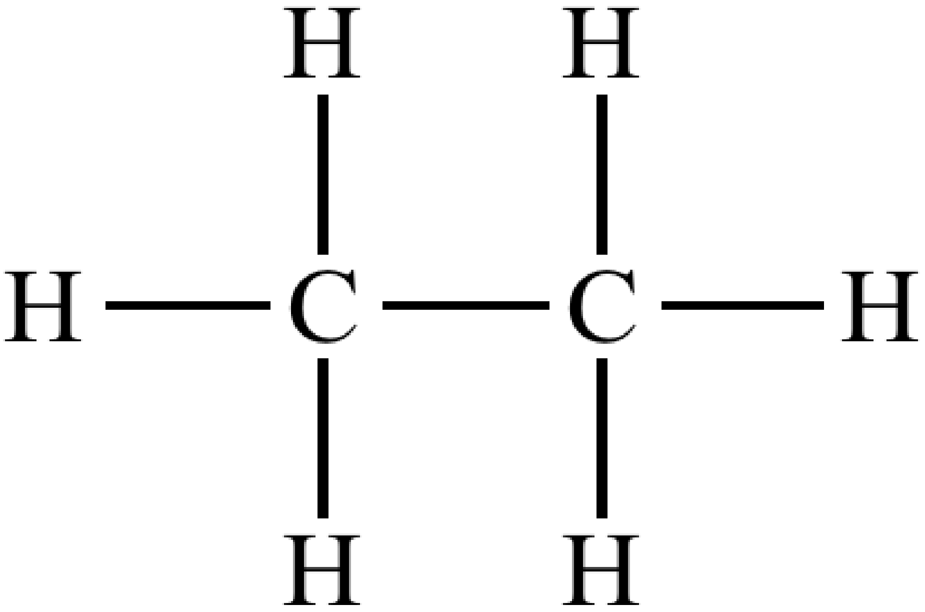
But if pi bonds aren’t as strong, why is a double/triple bond stronger than a single bond?

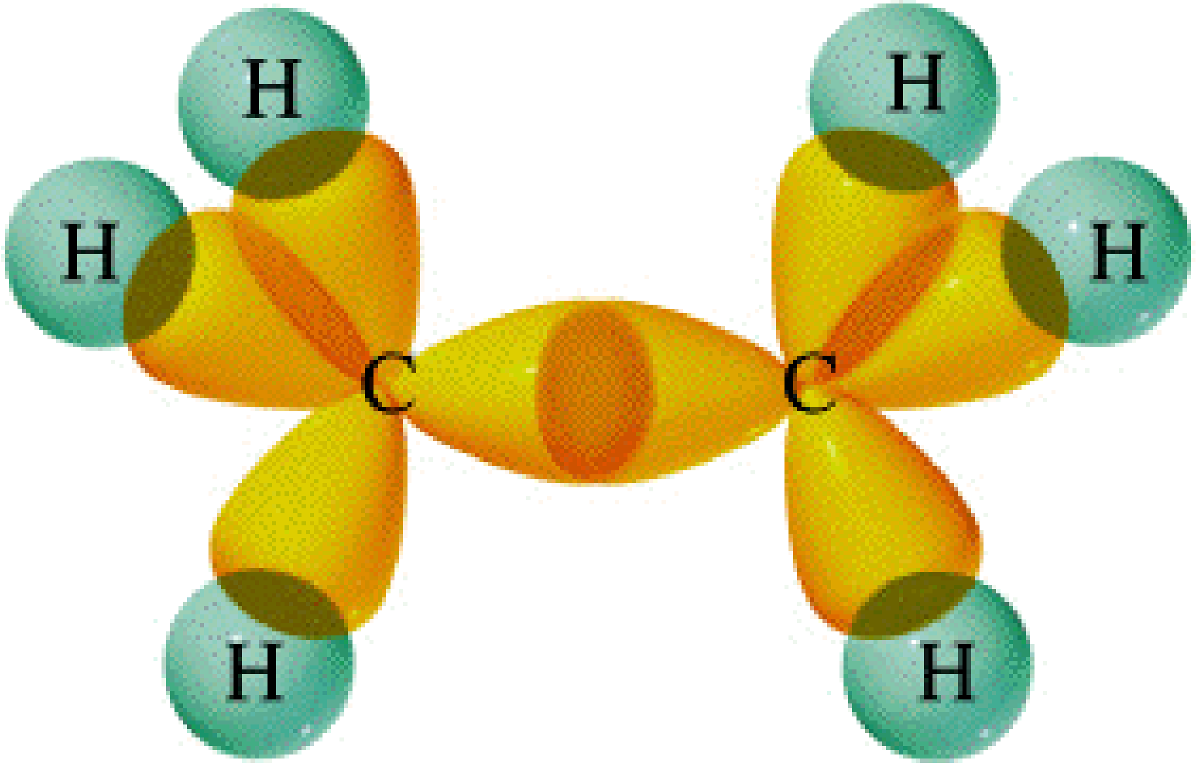
Because there are MORE bonds present, a sigma plus a pi is still stronger than just a sigma!

Example: Ethane

6 single bonds

6 σ bonds





Example: Ethene

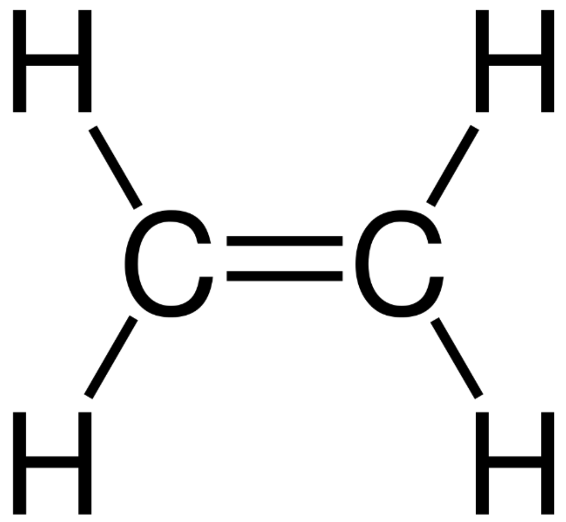
4 single bonds
4 σ bonds

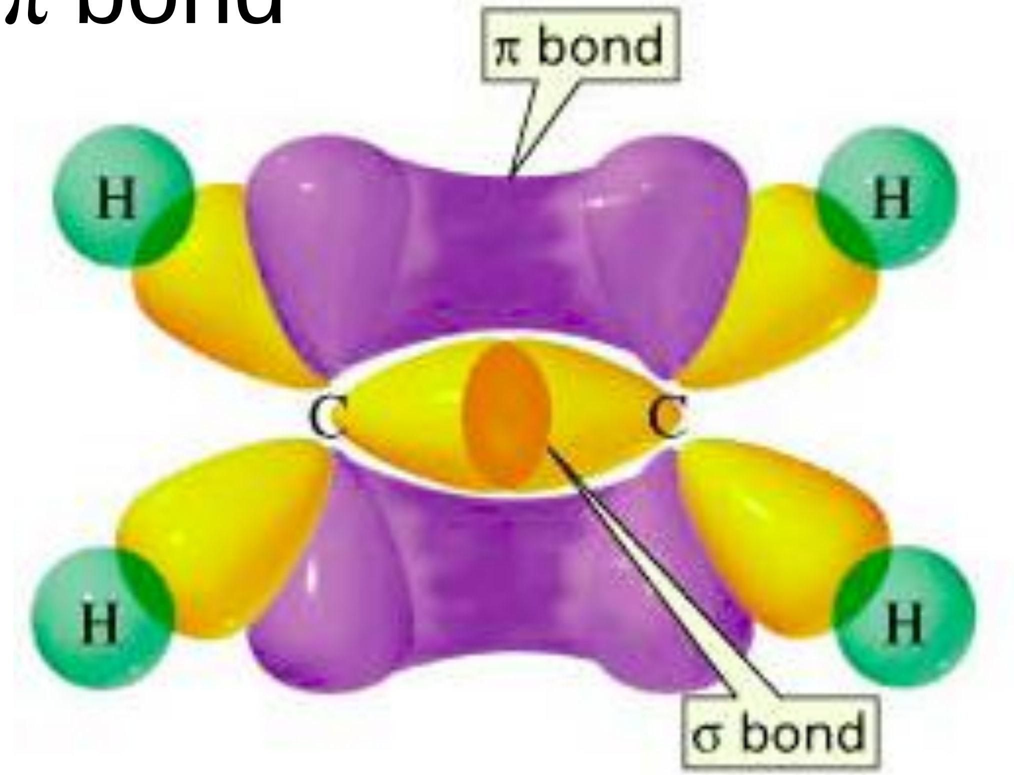
+

1 double bond
1 σ bond
1 π bond

=

5 σ bonds
1 π bond





Example: Ethene

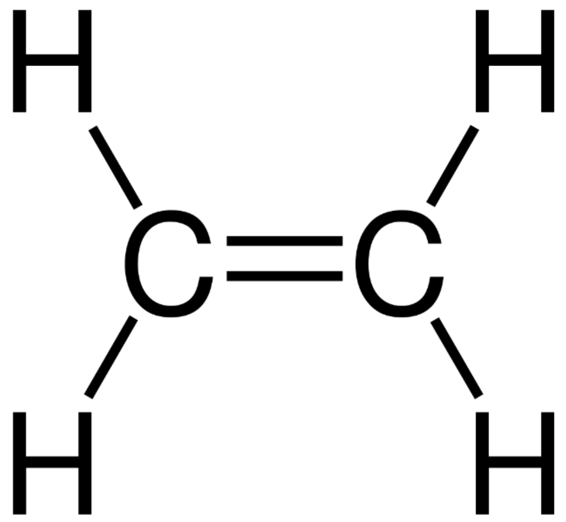
4 single bonds
4 σ bonds

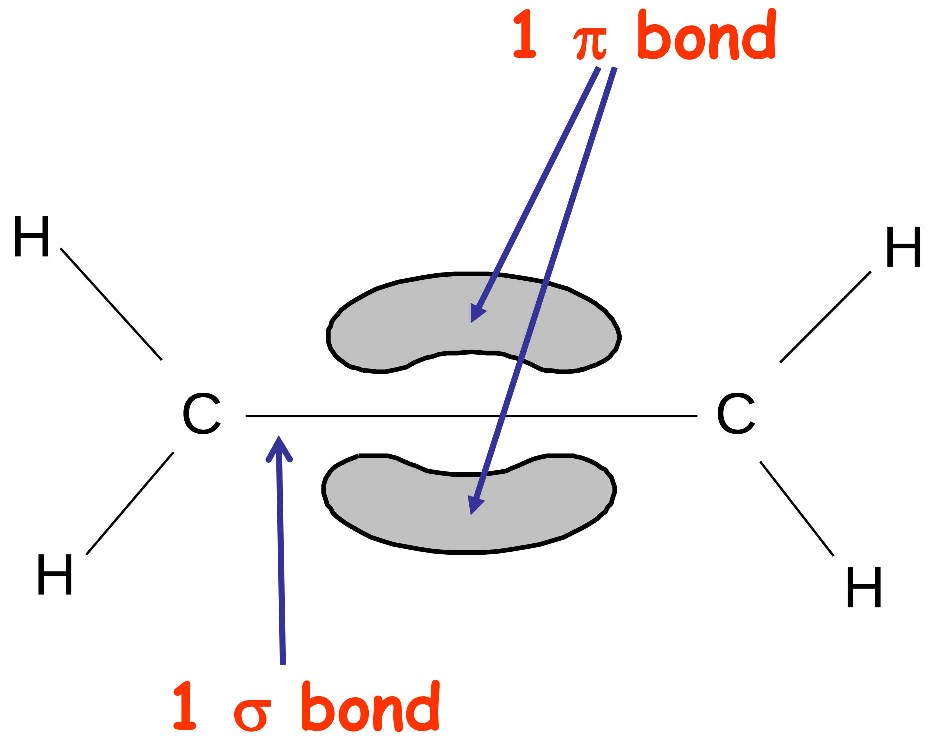
\+

1 double bond
1 σ bond
1 π bond

=

5 σ bonds
1 π bond





***** The pi bond is on top and bottom – that is ONE pi bond not two.**

Example: Ethyne

2 single bonds
2 σ bonds

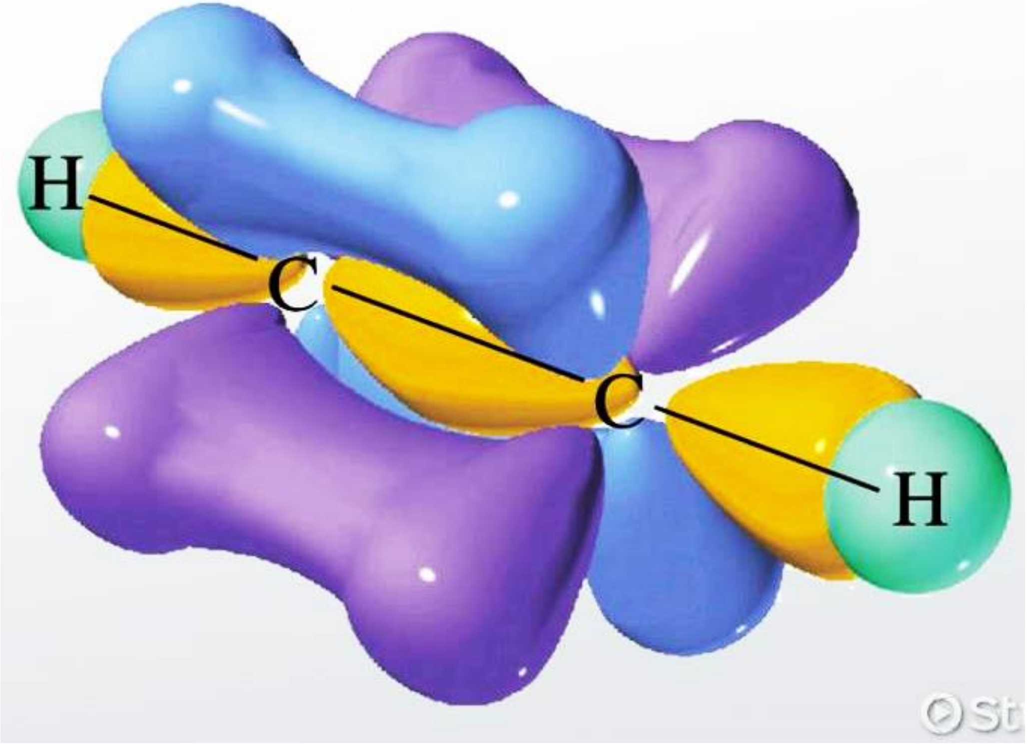
+

1 triple bond
1 σ bond
2 π bonds

=

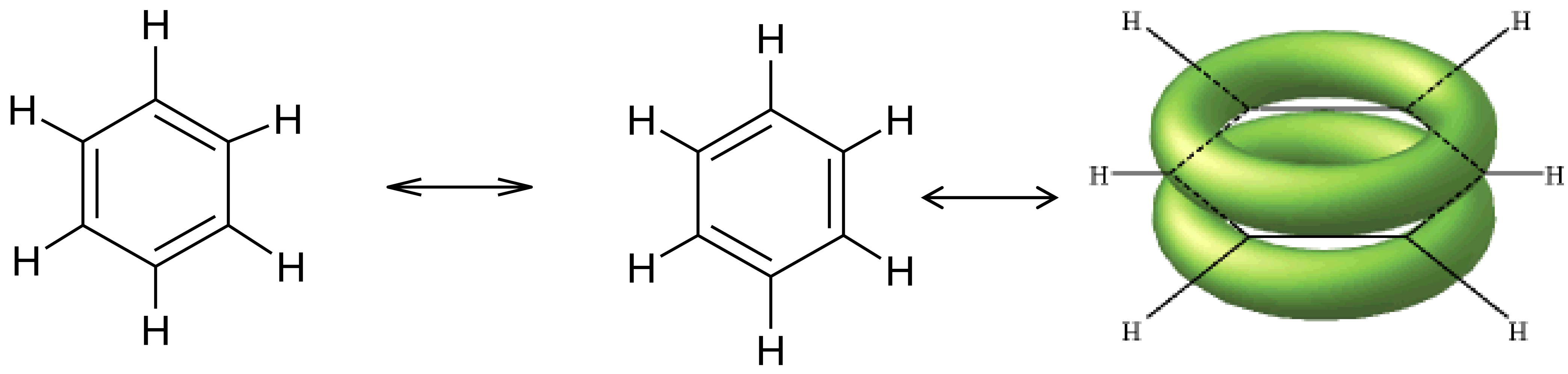
3 σ bonds
2 π bonds

H—C≡C—H



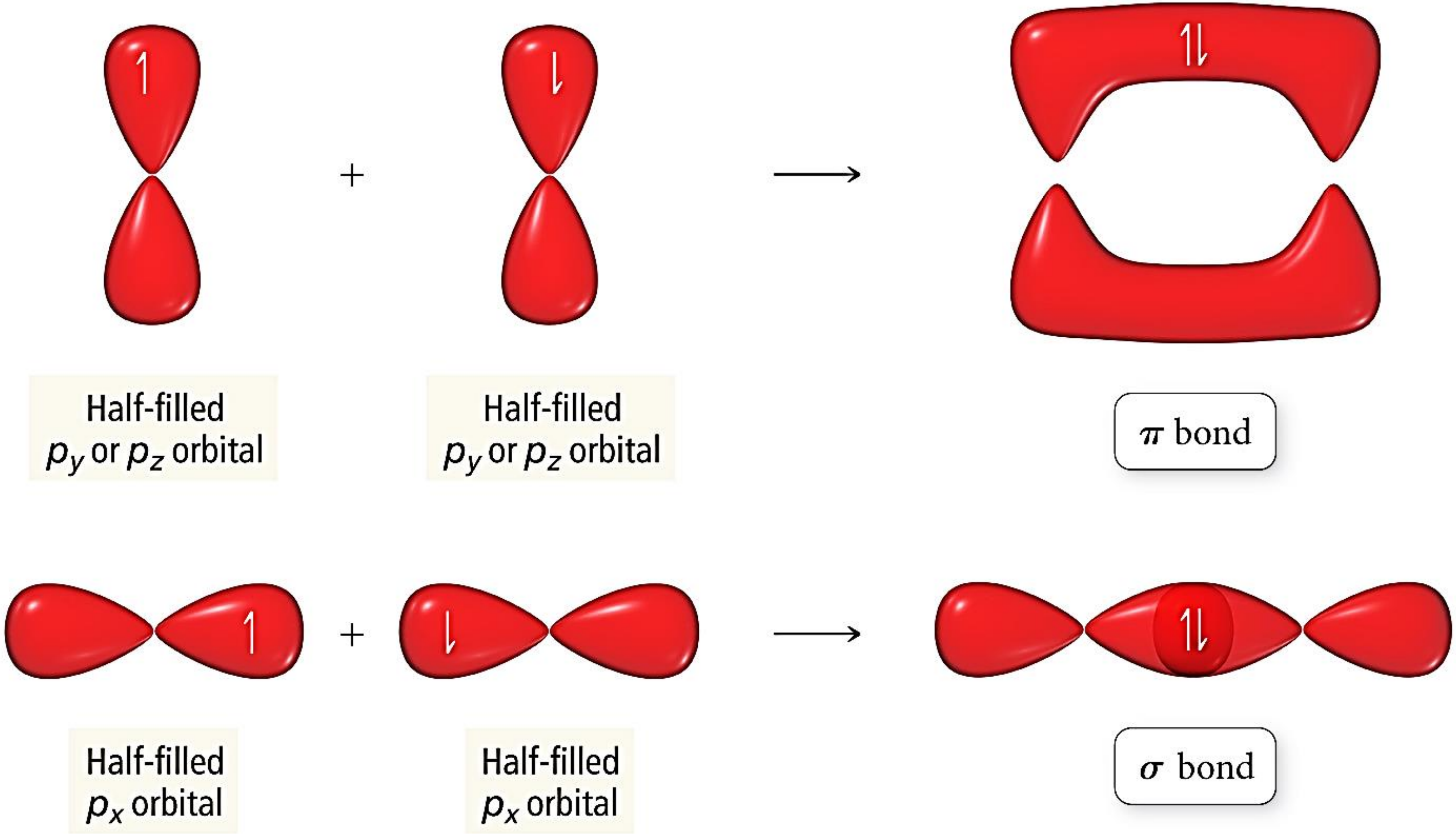
The De-Localized Electron Model

Pi bonds (π) contribute to the delocalized model of electrons in bonding, and help explain resonance

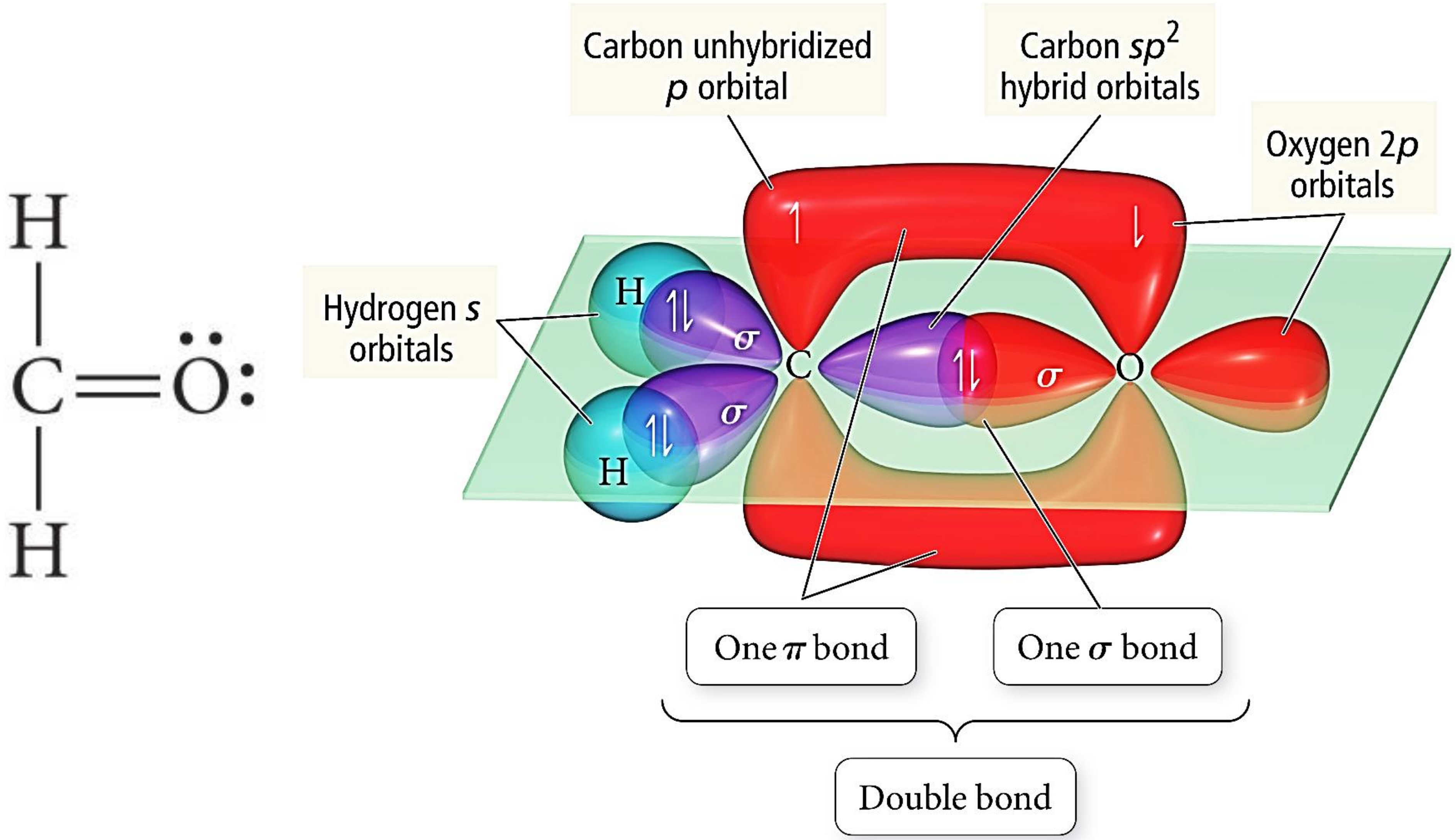


Electron density from π bonds can be distributed symmetrically all around the ring, above and below the plane.

Looking at which orbitals are overlapping

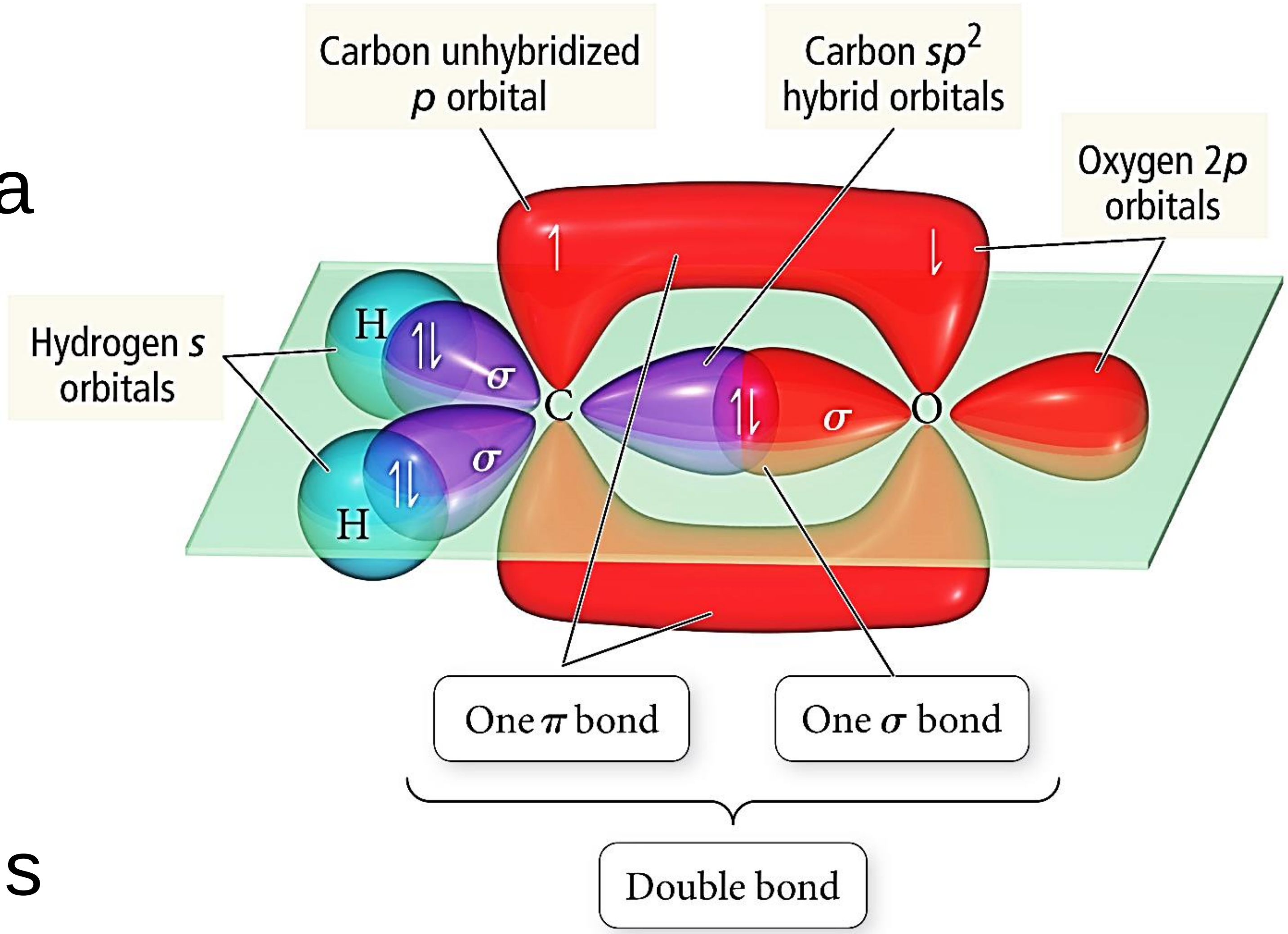


Looking at which orbitals are overlapping



Looking at which orbitals are overlapping

σ Bond - Overlap between a hybrid orbital on one atom and either a hybrid or nonhybridized orbital on another atom



π Bond – Overlap between unhybridized *p* orbitals on bonded atoms

Looking at which orbitals are overlapping

$$H-C\equiv C-H$$